

PRELIMINARY DATA SUMMARY

December 1989

U.S. Army Engineer Waterways Experiment Station
Coastal Engineering Research Center
Field Research Facility
Duck, North Carolina

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PART I: INTRODUCTION

The U.S. Army Engineer Waterways Experiment Station, Coastal Engineering Research Center's (CERC's) Field Research Facility (FRF) is located on the Outer Banks of North Carolina, near the village of Duck (Figure 1).

The FRF research program provides a means for obtaining high-quality field data, particularly during storms, in support of the U.S. Army Corps of Engineers' coastal engineering research missions. The research pier is a reinforced concrete structure supported on 0.9-m-diam steel piles spaced 12.2 m apart along the pier's length and 4.6 m apart across the width. The pier deck is 6.1 m wide and extends from behind the duneline to about the 6-m water depth contour at a height of 7.6 m above the National Geodetic Vertical Datum (NGVD). In addition, a main building contains offices, an instrument repair shop, and a data acquisition room.

One of the responsibilities of the FRF research program is the collection, analysis and dissemination of data on local oceanographic and meteorological conditions. Bottom profiles along both sides of the pier and periodic bathymetric surveys are also performed.

This summary is intended to provide basic data as soon as possible after they are obtained. Questions and/or comments concerning the data may be directed to Mr. Michael W. Leffler at (919) 261-3511.

Part II presents the meteorological data; Parts III through VI present oceanographic data; Part VII presents nearshore profiles and bathymetry; and Part VIII, if included, documents special events that occurred at the FRF during the month.

Table 1 is a list of instruments used, their operational status during the month, and the data collection status. Figure 2 identifies the location of the instruments. The water depths at the wave gages and current meters vary and may be determined from information contained in Figure 7. Other installation information is contained in Table 1.

Times given in the report, unless otherwise specified, are referenced to eastern standard time (EST).

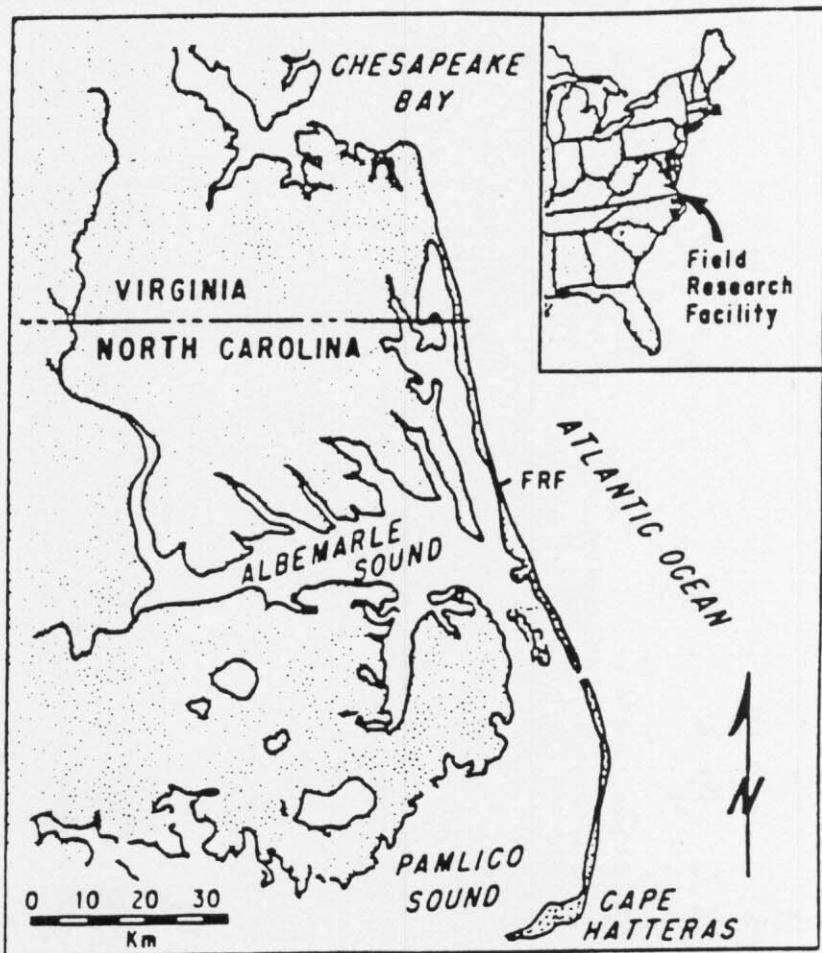
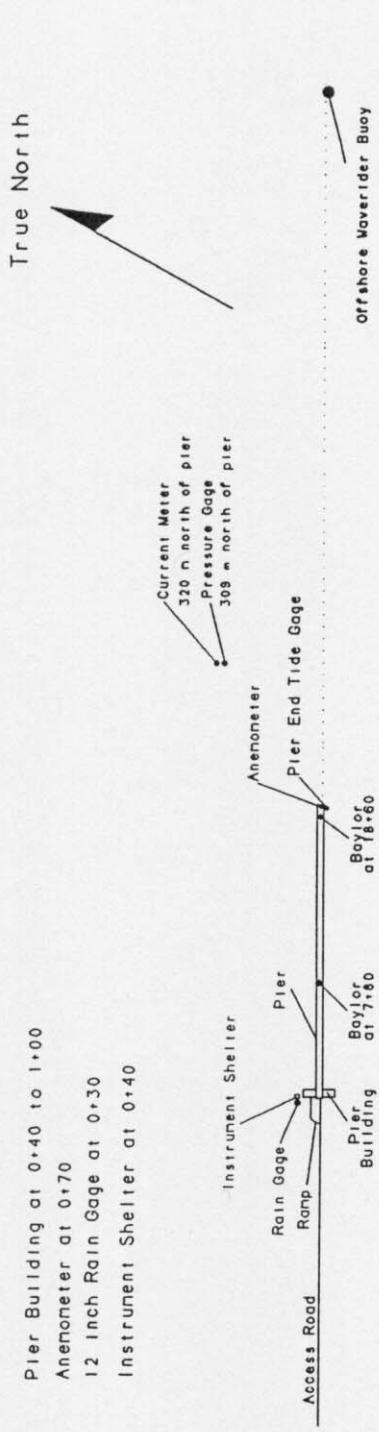


Figure 1. FRF Location Map

Table 1: Instrument Status/Data Availability

DEC 1989

Gage Status	Daily Observation	Analog Record	Data Collected
Operational = *	Complete = *	Complete = *	All = *
Partial = /	Partial = /	Partial = /	Partial = /
Non-Operational = -	None = -	None = -	None = -



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ATLANTIC OCEAN

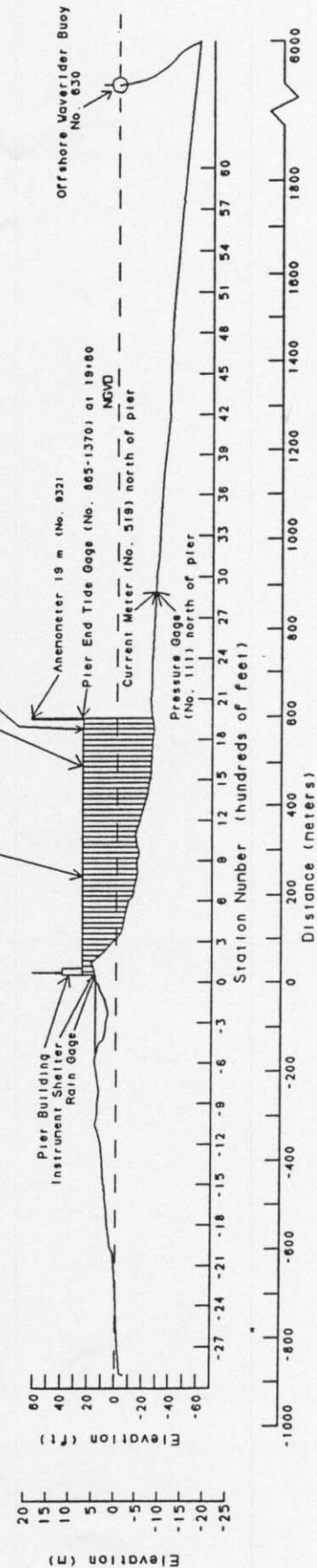


Figure 2. Instrument locations at FRF (all elevations from NGVD, all distances from FRF baseline).

PART II: METEOROLOGICAL DATA

A variety of instruments have been installed at the FRF (Figure 2) to monitor the meteorological conditions. The data presented in Table 2 are collected and stored on magnetic tape using a Digital Equipment Corporation VAX 11/750. For each instrument identified in Table 1 as having analog outputs, chart records are obtained, a log is maintained and the records are stored for future reference.

Winds were measured at the end of the pier at an elevation of 19 m (Figure 2) using a Weather Measure Skyvane anemometer.

Monthly resultant wind speeds and directions are determined by vector averaging the data. Temperature and atmospheric pressure means are the average of the values presented for the month. Total precipitation is the sum for the month.

The following may be useful for converting the data in Table 2 to other frequently used units of measurement:

1. Millimeters (mm) to inches (in.) -
 $mm \times .03937 = in.$
2. Millibars (mb) to inches of mercury (in. Hg) -
 $mb \times 0.02953 = in. Hg$
3. Degrees Celsius (C) to degrees Fahrenheit (F) -
 $(C \times 9/5) + 32 = F$
4. Meters per second (m/s) to knots (kn) -
 $m/s \times 1.943 = kn$

Table 2: Meteorological Data

Dec 1989

Day	Hour	** Wind	** Wind	Temperature	Atm	Precipitation ***
		Speed m/sec	Direction deg TN	deg C	Pressure mb	mm
1	100	9	358	7.5	1015.9	0
	700	3	311	5.0	1019.6	0
	1300	3	249	9.9	1020.3	0
	1900	2	109	6.5	1022.3	0
2	100	5	167	6.9	1021.3	0
	700	2	177	5.0	1020.9	0
	1300	6	197	12.8	1014.5	0
	1900	8	196	12.6	1007.4	0
3	100	8	247	9.8	1002.3	0
	700	10	294	5.0	1005.0	0
	1300	12	298	4.3	1005.7	0
	1900	12	295	1.7	1009.1	0
4	100	14	301	-2.7	1012.1	0
	700	9	290	-3.4	1015.9	0
	1300		Maintenance			0
	1900	3	59	2.8	1009.4	0
5	100	3	61	5.3	1005.0	0
	700	3	62	4.1	1006.4	0
	1300	2	41	8.8	1005.4	0
	1900	2	51	7.7	1007.4	0
6	100	2	51	6.2	1008.7	0
	700	2	51	7.3	1009.8	0
	1300	2	52	16.3	1006.4	0
	1900	2	52	12.0	1006.4	0
7	100	3	53	10.6	1008.1	0
	700	4	132	11.6	1015.9	0
	1300	10	10	9.9	1020.3	0
	1900	10	27	8.6	1024.0	0
8	100	12	35	7.5	1024.3	0
	700	16	33	5.7	1021.9	9
	1300	15	45	7.4	1014.5	0
	1900	19	22	7.3	1011.8	0
9	100	17	19	7.0	1010.8	0
	700	16	18	6.9	1012.1	35
	1300	17	27	6.7	1009.1	0
	1900	19	24	8.0	1003.7	0
10	100	18	358	7.4	1004.3	0
	700	13	333	2.6	1011.1	21
	1300	7	336	5.3	1013.1	0
	1900	1	335	2.2	1015.2	0
11	100	4	236	1.7	1014.8	0
	700	7	242	1.4	1015.9	0
	1300	9	246	4.1	1013.5	0
	1900	3	253	3.5	1014.8	0
12	100	1	251	4.2	1015.2	0
	700	3	93	5.4	1013.1	0
	1300	8	344	6.4	1010.4	0
	1900	5	27	8.6	1007.0	0
13	100	15	341	5.0	1004.0	0
	700	14	1	7.2	1003.3	4
	1300	*		3.3	1006.4	0
	1900	9	325	1.6	1013.5	0
14	100	4	277	0.0	1016.5	0
	700	5	274	0.1	1018.6	15
	1300	7	251	3.2	1016.9	0
	1900	2	236	2.4	1017.5	0
15	100	1	269	1.0	1018.6	0
	700	2	232	2.3	1020.3	0
	1300	8	142	9.5	1014.5	0
	1900	9	184	7.5	1007.7	0
16	100	7	238	8.8	1006.0	0
	700	11	314	-2.0	1013.5	0
	1300	9	311	-0.9	1016.5	0
	1900					0

* electronic problems

(Continued)

Table 2: Meteorological Data

Dec 1989

Day	Hour	** Wind	** Wind	Temperature	Atm Pressure	Precipitation ***
		Speed m/sec	Direction deg TN			mm
17	100			Hardware Error		
	700					0
	1300	6	333		-1.4	1022.6
	1900	4	295		-2.0	1023.3
18	100	5	302	-2.4	1022.6	0
	700	6	319	-1.8	1023.3	0
	1300	9	342	-0.8	1023.3	0
	1900	9	337	-2.6	1025.0	0
19	100	8	18	1.3	1024.3	0
	700	8	33	3.2	1023.0	0
	1300	6	31	5.5	1016.2	0
	1900	9	2	5.0	1013.8	0
20	100	10	326	0.1	1012.5	0
	700	10	321	-1.7	1016.9	10
	1300	13	342	1.0	1019.2	0
	1900	4	294	-1.0	1021.9	0
21	100	2	247	-2.3	1021.3	0
	700	1	261	-2.8	1020.6	0
	1300	5	255	3.3	1016.9	0
	1900	5	306	1.0	1017.5	0
22	100	16	349	-3.6	1022.6	0
	700	14	321	-9.1	1027.7	0
	1300	12	343	-6.4	1028.0	0
	1900	10	317	-7.1	1029.7	0
23	100	12	347	-5.5	1028.4	0
	700	15	349	-5.6	1028.4	3
	1300	17	355	-3.8	1024.7	0
	1900	20	359	-1.8	1023.0	0
24	100	20	352	-2.3	1018.9	0
	700	22	351	-1.5	1014.8	15
	1300	22	346	-2.2	1013.1	0
	1900	18	339	-6.2	1016.9	0
25	100	6	310	-7.9	1018.2	0
	700	5	290	-9.6	1019.2	0
	1300	4	224	-4.0	1016.9	0
	1900	6	183	-3.1	1013.1	0
26	100	4	209	-1.0	1009.1	0
	700	7	228	-1.8	1007.7	0
	1300	10	243	3.1	1007.0	0
	1900	4	265	1.2	1011.8	0
27	100	9	360	-0.4	1017.9	0
	700	8	13	-2.5	1021.9	0
	1300	1	93	1.1	1019.9	0
	1900	3	287	0.4	1015.9	0
28	100	2	206	-0.4	1013.5	0
	700	4	276	-0.9	1015.9	0
	1300	3	328	3.9	1019.2	0
	1900	3	131	1.1	1021.9	0
29	100	4	183	0.9	1023.0	0
	700	2	234	-1.0	1024.0	0
	1300	3	76	6.6	1022.6	0
	1900	4	143	5.0	1021.6	0
30	100	6	205	6.2	1019.6	0
	700	4	192	5.5	1019.9	0
	1300	5	235	9.4	1018.9	0
	1900	3	247	5.4	1019.9	0
31	100	5	206	9.4	1018.9	0
	700	5	149	4.6	1015.9	0
	1300	13	181	15.9	1011.1	0
	1900	12	185	14.0	1007.7	0
		Resultant		Mean	Mean	Total
		4	337	3.0	1015.7	112

* electronic problems

(Sheet 2 of 2)

** Anemometer at end of pier used (gage No. 932)

*** Precipitation amounts obtained from backup rain gage

PART III: WAVE DATA

Wave data are collected from two Baylor staff gages (Gages 625 and 645), a pressure wave gage (Gage 111) and a Waverider buoy (Gage 630) as shown in Table 1 and Figure 2. The data are collected, analyzed, and stored on magnetic tape using a Digital Equipment Corporation VAX 11/750 programmed to sample the wave gages every 6 hr (more frequently during storms) beginning at 0100, 0700, 1300, and 1900 EST. The sampling rate is two times per second for four contiguous 34-min records.

Wave height H_{mo} is an energy-based statistic equal to four times the standard deviation of the sea surface elevations. Wave height reported from the pressure gage has been compensated for hydrodynamic attenuation using linear wave theory. Wave period is identified from the computation of a variance (energy) spectrum with 60 deg of freedom calculated from a 34-min record. Peak wave period T_p is defined as the period associated with the maximum energy in the spectrum. When this analysis is complete, the data are written to magnetic tape.

Table 3 presents the wave heights and periods for each wave record obtained at 6 hr intervals during the month. The monthly means and standard deviations from the means shown in Table 3 are average values computed from this data. Figure 3 is a time history of all H_{mo} and T_p values obtained for all gages.

Differences in wave periods between wave gages (Table 3 and Figure 3) may be the result of wave breaking, wave reformation, or the presence of multiple wave trains containing nearly equal energy.

Table 3: Wave Data

Dec 1989

Day	Hour	645		625		111		630	
		Baylor at 7+80 Hmo,m	T,sec	Baylor at 18+60 Hmo,m	T,sec	Pressure Gage Hmo,m	T,sec	Offshr Wvrdr Hmo,m	T,sec
1	0100	0.29	12.80	0.23	11.64	0.50	3.20		
	0700	1.21	6.92	1.32	6.56	1.48	5.95		
	1300	0.69	5.95	0.79	6.74	0.90	6.74		
	1900	0.52	5.33	0.55	5.12	0.63	5.45		
2	0100	0.48	6.92	0.49	7.11	0.54	7.53		
	0700	0.54	5.69	0.55	5.95	0.63	6.09		
	1300	0.55	8.53	0.59	8.83	0.69	8.26		
	1900	0.59	8.53	0.57	8.26	0.77	8.53		
3	0100	0.46	9.14	0.47	10.67	0.72	4.92		
	0700	0.87	5.33	0.93	5.95	1.77	5.82		
	1300	1.06	6.74	1.21	6.92				
	1900	1.01	5.57	1.18	5.45				
4	0100	1.31	7.76	1.40	6.74				
	0700	1.08	8.00	1.04	6.74				
	1300			Maintenance					
	1900	0.53	8.83	*					
5	0100	0.34	8.00	*					
	0700	0.30	7.53	*					
	1300			Maintenance					
	1900	0.32	12.19	0.35	9.48				
6	0100	0.26	13.47	0.30	12.19				
	0700	0.27	13.47	0.28	13.47				
	1300	0.35	11.64	0.32	11.64				
	1900	0.42	12.80	0.44	3.41				
7	0100	0.35	7.31	0.36	7.31				
	0700	0.42	7.76	0.34	7.76				
	1300			Maintenance					
	1900	*		1.35	6.24				
8	0100	*		1.51	5.22				
	0700	*		2.22	6.40				
	1300	2.65	7.11	2.93	7.31				
	1900	2.87	8.53	3.95	7.76				
9	0100	3.02	9.85	4.01	10.24				
	0700	2.75	10.24	3.53	9.85				
	1300	2.85	11.13	3.71	10.67				
	1900	3.01	10.24	4.08	10.24				
10	0100	2.83	10.67	4.16	10.24	Gage			
	0700	2.97	11.13	3.32	10.67	Inoperative			
	1300	2.24	11.13	*					
	1900	1.72	11.13	1.97	11.13				
11	0100	1.41	10.67	1.66	10.67				
	0700	1.20	10.67	1.32	10.24				
	1300	0.89	10.67	0.96	9.48				
	1900	0.24	10.24	0.69	10.24				
12	0100	0.20	9.85	0.47	10.24	0.53	9.48		
	0700	0.24	9.85	0.44	9.48	0.51	9.85		
	1300	0.36	2.67	0.54	9.48	0.42	9.85		
	1900	0.41	3.08	0.57	9.48	0.44	9.85		
13	0100	1.32	5.69	1.15	5.69	1.47	5.69		
	0700	2.16	7.31	2.29	7.31	2.55	7.31		
	1300	1.69	9.14	2.38	9.85	2.93	9.14		
	1900	1.78	9.85	2.15	9.85	2.47	9.85		
14	0100	*		1.53	9.48	1.74	9.48		
	0700	0.88	8.83	1.13	8.83	1.36	11.13		
	1300	*		0.89	11.13	0.99	11.64		
	1900	0.43	10.67	0.74	10.24	0.95	10.24		
15	0100	*		0.60	10.24	0.73	10.24		
	0700	0.37	9.85	0.47	9.85	0.54	9.85		
	1300	*		0.52	10.24	0.43	9.85		
	1900	*		0.39	16.00	0.39	16.00		
16	0100	*		0.35	16.00	0.40	5.95		
	0700	*		1.11	5.57	1.30	5.57		
	1300	1.31	6.56	1.08	6.24	1.28	6.24		
	1900								

* Electronic problems

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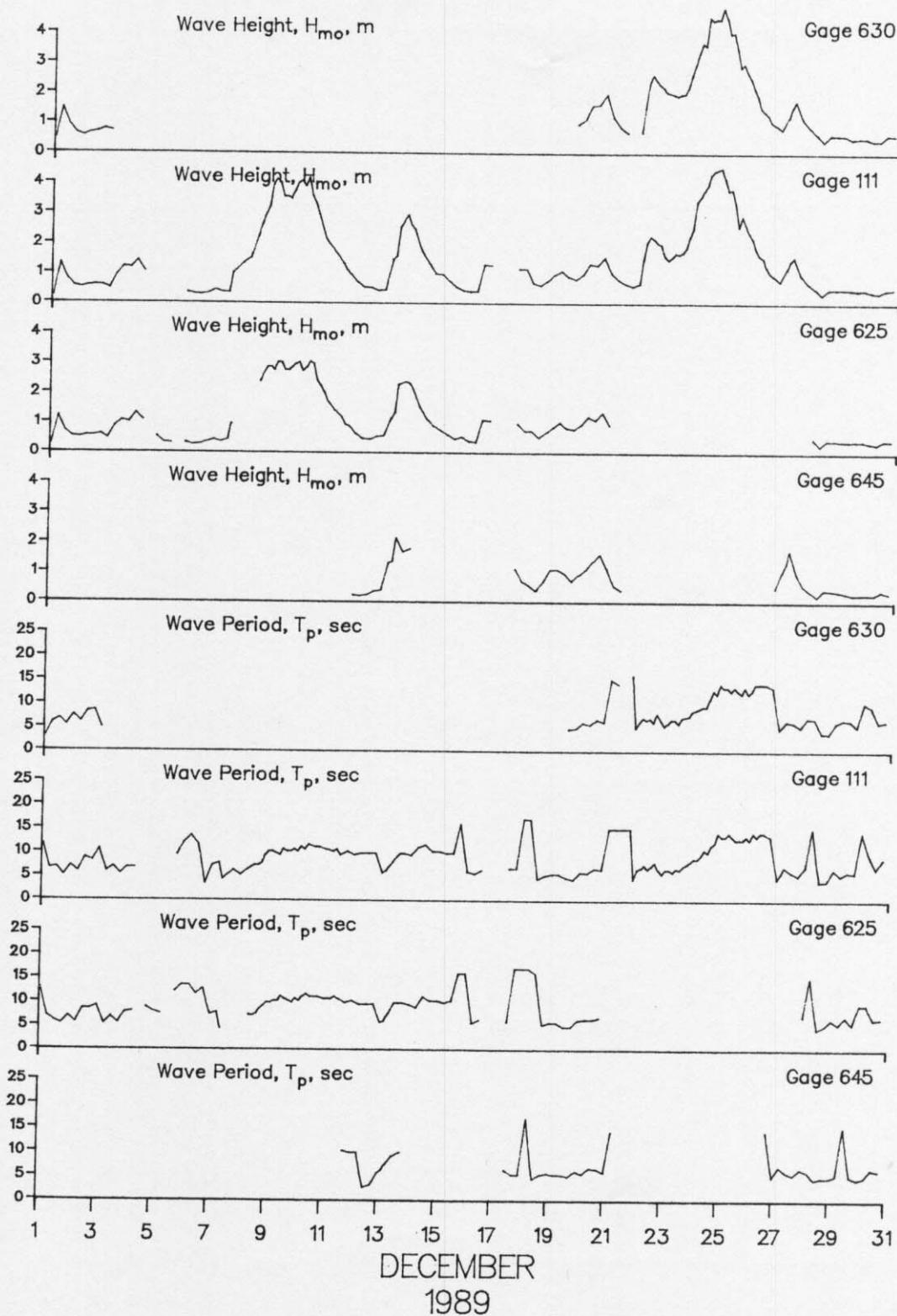
Table 3: Wave Data

Dec 1989

Day	Hour	645		625		111		630	
		Baylor at 7+80	Hmo,m	Baylor at 18+60	Hmo,m	Pressure Gage	T.sec	Offshr Wvrdr	Hmo,m
17	0100								
	0700					Hardware Error			
	1300	1.12	6.40	0.99	5.95	1.16	6.74		
	1900	0.70	5.45	0.74	17.07	0.80	18.29		
18	0100	0.56	5.33	0.56	18.29	0.69	17.07		
	0700	0.38	17.07	0.52	17.07	0.60	17.07		
	1300	0.69	4.49	0.68	16.00	0.75	4.49		
	1900	1.10	5.33	0.86	5.22	0.97	5.22		
19	0100	1.12	5.69	1.03	5.69	1.10	5.57		
	0700	0.98	5.45	0.84	5.69	0.90	5.57		
	1300	0.71	5.33	0.79	4.83	0.81	4.83	0.98	4.74
	1900	0.93	5.02	0.96	4.83	0.98	4.41	1.13	4.92
20	0100	1.10	6.09	1.23	6.24	1.33	5.95	1.59	6.09
	0700	1.39	5.57	1.12	6.40	1.29	5.82	1.63	5.69
	1300	1.61	6.74	1.36	6.40	1.55	6.74	1.96	6.74
	1900	1.10	6.56	0.94	6.74	1.02	6.56	1.20	6.24
21	0100	0.54	5.82	0.72	5.57	0.79	15.06	0.87	15.06
	0700	0.40	14.22	0.66	14.22	0.66	15.06	0.69	14.22
	1300					0.58	15.06	*	
	1900					0.67	15.06	0.72	16.00
22	0100					2.07	6.56	2.33	6.24
	0700					2.17	7.53	2.43	6.74
	1300					1.99	7.31	2.19	6.24
	1900					1.47	6.56	2.09	6.92
23	0100					1.68	6.56	1.90	5.95
	0700					1.72	6.09	1.98	6.74
	1300					2.26	6.56	2.60	7.11
	1900			Gage		3.43	7.76	3.34	7.53
24	0100			Inoperative		3.77	8.83	3.58	8.83
	0700					4.32	9.48	4.43	9.48
	1300					4.48	10.24	5.63	11.13
	1900			Gage		4.18	12.19	4.49	12.19
25	0100			Inoperative		3.79	13.47	4.00	13.47
	0700					2.58	14.22	2.87	12.80
	1300					2.63	12.80	2.68	12.80
	1900					2.19	12.80	2.16	13.47
26	0100					1.62	12.80	1.50	12.80
	0700					1.24	13.47	1.28	14.22
	1300					0.95	14.22	0.98	14.22
	1900	0.50	14.22			0.77	13.47	0.81	13.47
27	0100	1.04	4.83			1.18	4.57	1.23	4.74
	0700	1.75	7.11			1.56	7.11	1.74	6.40
	1300	0.99	5.95			0.98	6.09	1.14	6.09
	1900	0.55	5.33	0.61	5.22	0.69	5.33	0.87	5.22
28	0100	0.37	6.56	0.50	7.11	0.53	7.11	0.65	7.11
	0700	0.21	6.09	0.27	15.06	0.31	15.06	0.42	6.92
	1300	0.44	4.41	0.45	4.34	0.49	4.00	0.63	3.94
	1900	0.42	4.74	0.45	5.02	0.50	4.13	0.62	3.88
29	0100	0.37	4.74	0.42	6.40	0.50	6.56	0.61	6.09
	0700	0.32	5.33	0.41	5.45	0.49	5.33	0.50	6.74
	1300	0.27	15.06	0.41	6.92	0.46	6.09	0.52	6.56
	1900	0.27	5.12	0.42	5.45	0.47	5.82	0.52	5.33
30	0100	0.28	4.49	0.37	9.48	0.41	14.22	0.45	10.24
	0700	0.27	4.83	0.33	9.48	0.37	9.85	0.44	9.48
	1300	0.39	6.56	0.44	6.40	0.47	6.74	0.63	6.09
	1900	0.32	6.24	0.44	6.56	0.51	8.83	0.62	6.40
31	0100	0.34	6.09	0.41	9.48	0.46	6.09	0.57	5.95
	0700	0.35	9.48	0.44	9.48	0.50	9.85	0.57	9.85
	1300	0.50	9.48	0.51	9.85	0.54	9.85	0.72	9.48
	1900	0.69	7.31	0.79	7.53	0.91	8.83	1.36	6.56
	Mean	0.73	7.16	0.95	9.00	1.36	8.95	1.48	8.10
	Std dev	0.49	3.03	0.75	3.18	1.11	3.30	1.16	3.25

* Electronic problems

(Sheet 2 of 2)



PART IV: CURRENT DATA

Current data (Table 4) are collected from a Marsh-McBirney electromagnetic biaxial current meter (Table 1 and Figure 2) and by visually observing the movement of dye on the water surface in the surf and at the seaward end of the pier, as well as 500 m updrift of the pier 12 m offshore.

Since the shoreline orientation is approximately N20W, longshore currents flow either toward 340 deg (i.e. northward) or toward 160 deg (i.e. southward). Similarly, cross-shore currents are either onshore (westward) or offshore (eastward).

All current speeds are given in centimeters per second (cm/sec). Resultant speeds and directions are determined by vector averaging the data.

Table 4: Current Data
Dec 1989

Day	Alongshore Cross-shore Resultant Time	Pier Measurements				Beach Measurements (500m Updrift)				Current Meter	
		Dye at (579 m) (surface)	Distance from Baseline (m)	Speed	Dir	Dye 12m offshore (surface)	Location	Speed	Dir	Depth -5.6m (NGVD)	ID #519
1	0100-Along Cross Result									12	S
										6	off
										13	133
1	0700-Along Cross Result	5 S 1 off 5 154	152	102 20 104	S off 149		North	52	S	7	S
										3	off
										8	137
1	1300-Along Cross Result									3	S
										1	off
										3	142
1	1900-Along Cross Result									3	N
										0	
										3	340
2	0100-Along Cross Result									14	S
										5	off
										15	140
2	0700-Along Cross Result	0 20 off 20 70	140	4 1 4	N off 349		South	7	N	9	S
										2	off
										9	147
2	1300-Along Cross Result									11	S
										5	off
										12	136
2	1900-Along Cross Result									2	S
										3	on
										4	216
3	0100-Along Cross Result									0	
										6	on
										6	
3	0700-Along Cross Result	36 S 11 off 37 143	154	102 15 103	S on 169		North	94	S	13	S
										1	off
										13	156
3	1300-Along Cross Result									22	S
										7	off
										23	142
3	1900-Along Cross Result									17	S
										5	off
										18	144
4	0100-Along Cross Result									27	S
										11	off
										29	138
4	0700-Along Cross Result	17 S 2 off 17 154	152	122 12 123	S off 154		North	63	S	7	S
										2	off
										7	144
4	1300-Along Cross Result										
4	1900-Along Cross Result										
5	0100-Along Cross Result										
5	0700-Along Cross Result	20 N 4 off 21 351	140	17 5 18	N off 357		South	9	N		
5	1300-Along Cross Result										
5	1900-Along Cross Result										

KEY = All speeds in cm/sec

N = Northward, Shore parallel

S = Southward, Shore parallel

on = onshore off = offshore

Table 4: Current Data (Continued)
Dec 1989

Alongshore Cross-shore Resultant Time Day	Pier Measurements				Beach Measurements (500m Updrift)				Current Meter		
	Dye at (579 m) (surface)	Speed	Dir	Dye at Mid-Surf Zone (surface)	Distance from Baseline (m)	Speed	Dir	Dye 12m offshore (surface)	Location	Speed	Dir
6 0100-Along Cross Result											
6 0700-Along Cross Result	13 5 14	N off 2		140	6 2 7	N off 2		13	N		
6 1300-Along Cross Result											
6 1900-Along Cross Result											
7 0100-Along Cross Result											
7 0700-Along Cross Result	16 0 16	S on 160		152	47 7 47	S off 151		97	S		
7 1300-Along Cross Result											
7 1900-Along Cross Result											
8 0100-Along Cross Result											
8 0700-Along Cross Result	61 12 62	S on 171		152	87 9 88	S on 166		91	S		
8 1300-Along Cross Result											
8 1900-Along Cross Result											
9 0100-Along Cross Result											
9 0700-Along Cross Result	76 11 77	S on 169		140	122 18 123	S off 151		134	N	39 33 51	S off 120
9 1300-Along Cross Result											
9 1900-Along Cross Result											
10 0100-Along Cross Result											
10 0700-Along Cross Result	41 4 41	S on 166		140	51 8 51	S on 169		30	S	31 36 48	S off 111
10 1300-Along Cross Result											
10 1900-Along Cross Result											

KEY = All speeds in cm/sec
 N = Northward, Shore parallel
 S = Southward, Shore parallel
 on = onshore off = offshore

Table 4: Current Data (Continued)
Dec 1989

Alongshore Cross-shore Resultant ---- Time	Pier Measurements				Beach Measurements (500m Updrift)				Current Meter		
	Dye at (579 m) (surface)	Speed	Dye at Distance from Baseline (m)	Speed	Dir	Dye 12m offshore (surface)	Location	Speed	Dir	0.9 km Offshore Depth -5.6m (NGVD) ID #519	
Day										Speed	Dir
11 0100-Along Cross Result										17	S on
11 0700-Along Cross Result	12 21 25	N off 40	152	76 46 89	N off 11		66	N		3 17	170
11 1300-Along Cross Result										12 17 21	N on 285
11 1900-Along Cross Result										13 8 15	N on 308
12 0100-Along Cross Result										13 5 14	N on 319
12 0700-Along Cross Result	20 20	N 340	128	14 1	N on 337		19	N		17 7 18	N on 318
12 1300-Along Cross Result										12 5 13	N on 317
12 1900-Along Cross Result										3 2 4	S off 126
13 0100-Along Cross Result										35 13 37	S off 140
13 0700-Along Cross Result	76 0 76	S on 160	140	152 15 153	S on 166		142	S		46 21 51	S off 135
13 1300-Along Cross Result										62 30 69	S off 134
13 1900-Along Cross Result										32 12 34	S off 139
14 0100-Along Cross Result										17 2 17	S off 153
14 0700-Along Cross Result	0 20 20		128	61 6 61	S on 166		67	S		12 18 22	N on 284
14 1300-Along Cross Result										6 9 11	N on 284
14 1900-Along Cross Result										6 6 8	N on 295
15 0100-Along Cross Result										12 7 14	S off 130
15 0700-Along Cross Result	6 1 6	S on 169	128	6 0 6	N 340		12	N		6 4 7	N on 306
15 1300-Along Cross Result										7 4 8	S off 130
15 1900-Along Cross Result										17 12 21	N on 305

KEY = All speeds in cm/sec

N = Northward, Shore parallel

S = Southward, Shore parallel

on = onshore off = offshore

Table 4: Current Data (Continued)
Dec 1989

Alongshore Cross-shore Resultant ---- Time	Pier Measurements				Beach Measurements (500m Updrift)				Current Meter		
	Dye at (579 m) (surface)	Speed	Dir	Dye at Mid-Surf Zone (surface)	Distance from Baseline (m)	Speed	Dir	Dye 12m offshore (surface)	Location	Speed	Dir
Day											
16 0100-Along Cross Result										13	N
										10	on
										16	302
16 0700-Along Cross Result	51	S		41	S			146	S	16	S
	15	off		0						5	off
	53	143		41	160					17	143
16 1300-Along Cross Result										23	S
										9	off
										25	139
16 1900-Along Cross Result											
17 0100-Along Cross Result											
17 0700-Along Cross Result	34	S		76	S			61	S		
	7	on		15	on						
	35	171		78	171						
17 1300-Along Cross Result										18	S
										8	off
										20	136
17 1900-Along Cross Result										0	
										3	on
										3	250
18 0100-Along Cross Result										2	N
										12	off
										12	61
18 0700-Along Cross Result	51	S		61	S			72	S	27	S
	10	on		18	on					12	off
	52	171		64	177					30	136
18 1300-Along Cross Result										41	S
										17	off
										44	137
18 1900-Along Cross Result										29	S
										10	off
										31	141
19 0100-Along Cross Result										31	S
										13	off
										34	137
19 0700-Along Cross Result	34	S		34	S			38	S	24	S
	5	on		0						11	off
	34	169		34	160					26	135
19 1300-Along Cross Result										22	S
										12	off
										25	131
19 1900-Along Cross Result										36	S
										14	off
										39	139
20 0100-Along Cross Result										31	S
										11	off
										33	140
20 0700-Along Cross Result	51	S		152	S			75	S	43	S
	10	on		46	on					17	off
	52	171		159	177					46	138
20 1300-Along Cross Result										45	S
										18	off
										48	138
20 1900-Along Cross Result										12	S
										1	off
										12	155

KEY = All speeds in cm/sec
N = Northward, Shore parallel
S = Southward, Shore parallel
on = onshore off = offshore

Table 4: Current Data (Continued)
Dec 1989

Alongshore Cross-shore Resultant Time	Pier Measurements				Beach Measurements (500m Updrift)				Current Meter		
	Dye at (579 m) (surface)	Speed	Dir	Dye at Mid-Surf Zone (surface)	Distance from Baseline (m)	Speed	Dir	Dye 12m offshore (surface)	Location	Speed	Dir
Day											
21 0100-Along Cross Result										8	S
21 0700-Along Cross Result	0				25	S		14	N	2	off
	13	off		140	5	off				8	146
	13	70			26	149		North		0	
21 1300-Along Cross Result										1	on
										1	250
21 1900-Along Cross Result										18	N
										11	on
										21	309
22 0100-Along Cross Result										3	N
										3	on
										4	295
22 0700-Along Cross Result	51	S			203	S		105	S	39	S
	5	off		152	10	on				16	off
	51	154			203	163		South		42	138
22 1300-Along Cross Result										39	S
										16	off
										42	138
22 1900-Along Cross Result										27	S
										11	off
										29	138
23 0100-Along Cross Result										34	S
										13	off
										36	139
23 0700-Along Cross Result	51	S			68	S		53	S	40	S
	8	off		177	27	on		North		17	off
	51	151			73	182				43	137
23 1300-Along Cross Result										48	S
										19	off
										52	138
23 1900-Along Cross Result										75	S
										34	off
										82	136
24 0100-Along Cross Result										89	S
										41	off
										98	135
24 0700-Along Cross Result										99	S
										47	off
										110	135
24 1300-Along Cross Result										108	S
										64	off
										126	129
24 1900-Along Cross Result										71	S
										41	off
										82	130
25 0100-Along Cross Result										20	S
										4	off
										20	149
25 0700-Along Cross Result	24	S			24	N		29	S	31	S
	7	on		250	4	off				14	off
	25	177			25	349		North		34	136
25 1300-Along Cross Result										5	S
										5	off
										7	115
25 1900-Along Cross Result										2	S
										4	on
										4	223

KEY = All speeds in cm/sec
N = Northward, Shore parallel
S = Southward, Shore parallel
on = onshore off = offshore

Table 4: Current Data (Continued)
Dec 1989

Alongshore Cross-shore Resultant	Pier Measurements				Beach Measurements				Current Meter	
	Dye at (579 m) (surface)	Distance from Baseline (m)	Dye at Mid-Surf Zone (surface)	(500m Updrift)	Dye 12m offshore (surface)	Location	Speed	Dir	0.9 km Offshore Depth -5.6m (NGVD) ID #519	
Time	Speed	Dir	Speed	Dir				Speed	Dir	
Day										
26 0100-Along Cross Result								21	N	
								7	on	
								22	322	
26 0700-Along Cross Result	20	N	51	S			34	N	25	N
	4	off	20	off						
	21	351	55	138						
26 1300-Along Cross Result									22	N
									14	on
									26	308
26 1900-Along Cross Result									14	N
									7	on
									16	313
27 0100-Along Cross Result									6	S
									3	off
									7	133
27 0700-Along Cross Result	23	S	102	S			46	S	16	S
	0	128	10	on					7	off
	23	160	102	166					17	136
27 1300-Along Cross Result									10	S
									5	off
									11	133
27 1900-Along Cross Result									1	S
									2	on
									2	223
28 0100-Along Cross Result									6	N
									3	on
									7	313
28 0700-Along Cross Result	13	S	24	S					12	N
	0	116	0						8	on
	13	160	24	160					14	306
28 1300-Along Cross Result									12	S
									7	off
									14	130
28 1900-Along Cross Result									19	S
									4	off
									19	148
29 0100-Along Cross Result									18	S
									9	off
									20	133
29 0700-Along Cross Result	17	S	3	S			0		3	S
	3	on	128	1	off				0	
	18	169	3	143					3	160
29 1300-Along Cross Result									7	S
									9	off
									11	108
29 1900-Along Cross Result									2	N
									2	on
									3	295
30 0100-Along Cross Result									13	S
									5	off
									14	139
30 0700-Along Cross Result	6	S	0				9	S	1	S
	2	off	128	0					1	off
	6	143	0	0					1	115
30 1300-Along Cross Result									9	S
									4	off
									10	136
30 1900-Along Cross Result									14	S
									4	off
									15	144

KEY = All speeds in cm/sec

N = Northward, Shore parallel

S = Southward, Shore parallel

on = onshore off = offshore

Table 4: Current Data (Concluded)
Dec 1989

Day	Alongshore Cross-shore Resultant Time	Pier Measurements				Beach Measurements			Current Meter	
		Dye at (579 m) (surface)	Distance from Baseline (m)	Dye at Zone (surface)	Speed	Dir	Dye 12m offshore (surface)	Location	Speed	Dir
31 0100	Along Cross Result								22	S
									11	off
									25	133
31 0700	Along Cross Result	5 1 5	S off 143	128	0 0 0		7 S North		13 3 13	S off 147
31 1300	Along Cross Result								14	S
									1	off
31 1900	Along Cross Result								14	156
									2	S
									6	on
									6	232

KEY = All speeds in cm/sec
 N = Northward, Shore parallel
 S = Southward, Shore parallel
 on = onshore off = offshore

PART V: SUPPLEMENTAL OBSERVATIONS

Visual wave direction measurements (Table 5) of both the primary wave train (i.e. that having the larger wave heights) and the secondary wave train (which must be clearly distinguishable as a wave train separate from the primary waves but not surface chop or capillary waves) are taken daily at the seaward end of the pier. The direction of the primary wave train just north of the seaward end of the pier is also determined using a Raytheon Marine Pathfinder radar and measuring the alignment of the wave crests at approximately the same location as the visual measurements. The pier axis (considered perpendicular to the beach at the FRF) is orientated 70 deg east of true north; consequently, wave angles greater than 70 deg indicate that the waves were coming from the south side of the pier.

The width of the surf zone (seawardmost breaker position to shoreline) is determined from the pier deck.

Measurements of surface water temperature, density, and visibility are also taken daily at the seaward end of the pier. A jar along with a thermometer is lowered about 0.3 m into the water and allowed to remain for at least one minute. The jar is removed, the temperature read, and a hydrometer is used to determine the density. A Secchi disc is used to determine the surface visibility.

Table 5: Supplemental Observations

Dec 1989

Day	Time	Wave Approach		Radar Wave Angle deg from True N	Width of Surf Zone,m	Water Characteristics at Pier End		
		Angle at Pier End deg from True N Primary	Secondary			Temp.,C	Density g/cc	Secchi Vis.,m
1	0745	40			87	12.2	1.0250	1.2
2	0945	95	30		47	11.7	1.0244	1.2
3	1230	30	15	25	89	12.2	1.0250	0.6
4	0715	40	0		84	10.6	1.0250	0.6
5	0830	110			37	10.6		0.9
6	0745	140			50	13.3		1.2
7	0650	10			46	13.3		0.9
8	0830	25	50	inoperative	479	12.2		0.3
9	1215	50		inoperative	497	8.9		0.3
10	1045	90	15	85	475	8.9		0.3
11	0815	85			215	10.0		0.3
12	0700	90			38	8.9		1.2
13	0915	30	20	45	345	7.8		0.3
14	0830	50	20		85	7.8		0.3
15	0815	105	30		37	7.8		0.9
16	1000	10			49	8.9		0.3
17	1040	10			85	7.2		0.3
18	0920	55	10	60	51	5.6		1.2
19	0745	30	50	55	46	5.6		1.2
20	0915	25		40	120	4.4	1.0202	0.3
21	0800	40			31	6.7	1.0223	0.6
22	0800	30		50	350	6.1	1.0241	0.6
23	0714	50		75	134	3.3	1.0236	0.3
24	no observations made							
25	1130	70		inoperative	366	2.8	1.0254	0.3
26	1300	85	60		96	4.4	1.0253	0.3
27	0730	15			177	3.9	1.0255	0.6
28	0753	350			9	4.4	1.0254	0.3
29	0835	50			12	3.5	1.0230	0.9
30	0855	100			6	3.5	1.0222	2.1
31	0840	90	120		23	3.3	1.0222	1.8

PART VI: WATER LEVELS

Since 1978, the National Oceanic and Atmospheric Administration (NOAA)/National Ocean Service (NOS) has operated a primary tide station (No. 865-1370) at the seaward end of the FRF pier. A Leupold-Stevens digital recording float-type tide gage is used to collect instantaneous water level data every 6 minutes throughout the month.

The variation in water level during the month is shown in Figure 4 along with a list of mean and extreme values. This presentation is useful in identifying effects of both meteorological and astronomical forces on the open coast water level.

Table 6 contains the time at the center of each 12.42-hr tidal cycle and the range, high, low, and mean water levels during each tidal cycle.

FRF Tide Heights

Dec 1989

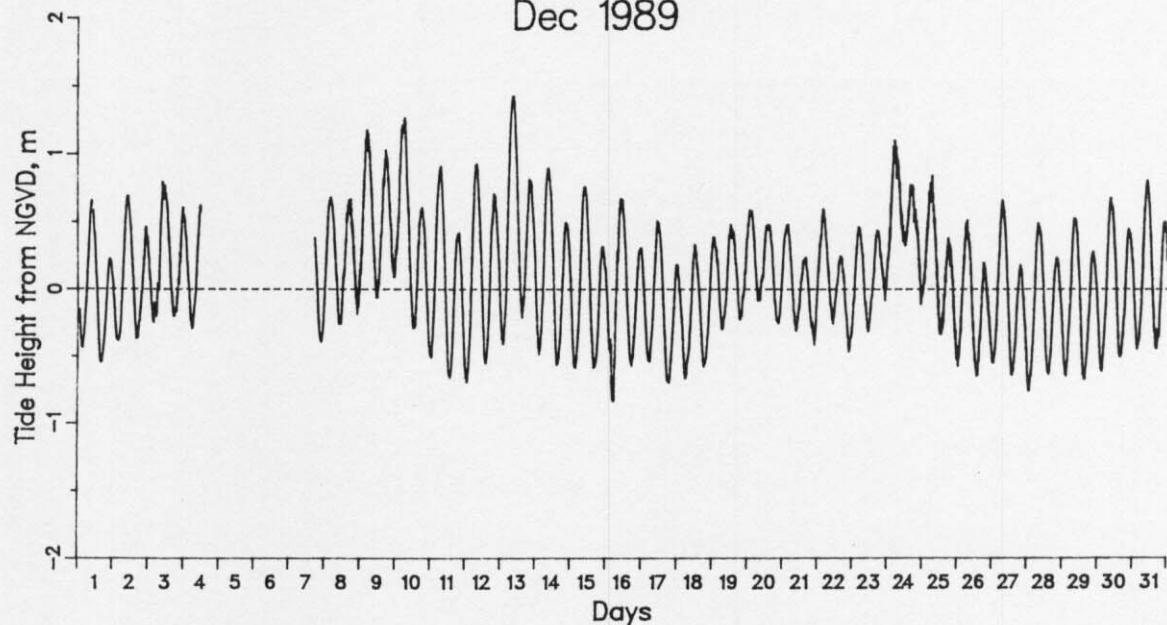


Figure 4. Water Level Time History

Monthly Water Levels, m NGVD

Extreme Low = -0.84 on day 16 at 436 EST
Extreme High = 1.43 on day 13 at 806 EST
Monthly Mean = 0.09
Mean Low = -0.42
Mean High = 0.61
Mean Range = 1.03

Table 6: Water Levels, m NGVD

		Dec 1989			
Mid-Cycle Day	Time	Low	High	Mean	Range
1	612	—	—	—	—
1	1837	-0.55	0.22	-0.15	0.77
2	703	-0.38	0.69	0.14	1.07
2	1928	-0.37	0.46	0.02	0.83
3	753	-0.25	0.80	0.28	1.05
3	2018	-0.20	0.61	0.16	0.81
4	843	—	—	—	—
4	2109	—	—	—	—
5	934	Installation of new tide house			
5	2159	and tide gage			
6	1024	—	—	—	—
6	2249	—	—	—	—
7	1115	—	—	—	—
7	2340	-0.39	0.68	0.16	1.08
8	1205	-0.26	0.67	0.21	0.93
9	30	-0.18	1.18	0.50	1.36
9	1255	-0.06	1.03	0.47	1.09
10	121	0.09	1.27	0.66	1.18
10	1346	-0.29	0.65	0.20	0.94
11	211	-0.51	0.91	0.19	1.42
11	1436	-0.66	0.42	-0.08	1.08
12	301	-0.69	0.93	0.11	1.62
12	1527	-0.55	0.71	0.10	1.26
13	352	-0.41	1.43	0.51	1.84
13	1617	-0.21	0.99	0.38	1.20
14	442	-0.48	0.90	0.23	1.38
14	1707	-0.56	0.50	0.00	1.06
15	532	-0.59	0.76	0.09	1.35
15	1758	-0.59	0.31	-0.11	0.90
16	623	-0.84	0.68	0.00	1.51
16	1848	-0.57	0.32	-0.09	0.89
17	713	-0.54	0.51	-0.03	1.05
17	1938	-0.69	0.18	-0.26	0.88
18	804	-0.66	0.33	-0.18	0.99
18	2029	-0.58	0.39	-0.11	0.97
19	854	-0.30	0.48	0.10	0.78
19	2119	-0.23	0.59	0.18	0.82
20	944	-0.09	0.48	0.22	0.56
20	2210	-0.25	0.48	0.11	0.73
21	1035	-0.31	0.31	0.00	0.62
21	2300	-0.41	0.60	0.08	1.01
22	1125	-0.26	0.35	0.05	0.61
22	2350	-0.46	0.46	-0.01	0.92
23	1216	-0.31	0.44	0.06	0.75
24	41	-0.09	1.10	0.48	1.19
24	1306	0.32	0.84	0.56	0.52
25	131	-0.11	0.84	0.35	0.95
25	1356	-0.33	0.53	0.06	0.86
26	222	-0.57	0.51	-0.03	1.09
26	1447	-0.65	0.20	-0.21	0.84
27	312	-0.55	0.66	0.02	1.21
27	1537	-0.64	0.18	-0.20	0.82
28	402	-0.76	0.49	-0.13	1.25
28	1628	-0.63	0.23	-0.18	0.86
29	453	-0.65	0.52	-0.04	1.17
29	1718	-0.67	0.28	-0.18	0.95
30	543	-0.61	0.68	0.04	1.29
30	1808	-0.50	0.45	-0.02	0.95
31	634	-0.45	0.81	0.18	1.26
31	1859	-0.44	0.50	0.04	0.94

PART VII: NEARSHORE PROFILES

A. Nearshore Profiles. In order to document profile response away from the pier, surveys of four profile lines extending 900 to 1,000 m from shore and located 489 and 581 m north and 517 and 608 m south of the FRF pier are conducted bi-weekly, after storms, and during more complete bathymetric surveys.

These profiles are obtained using the CRAB-Zeiss surveying system; a Zeiss Elta-2 first-order, self-recording electronic theodolite distance meter in combination with the Coastal Research Amphibious Buggy (CRAB), a 10.7 m high, self-powered, mobile tripod on wheels.

Figure 5 shows the last survey in November and the four surveys in December on profile line 188, located 517 m south of the pier. Two strong storms in December caused significant changes to the profile. On the foreshore (60 - 120 m) the berm (80 m) moved shoreward then was completely removed by the second storm. The most notable change to the beach face (80 - 120 m) was a dramatic steepening followed by up to 1 meter of accretion. The nearshore bar (120 - 260 m) was repeatedly reshaped, then by the end of the month it had completely disappeared. Important changes offshore were generally caused by the second storm. These included, the development of a prominent storm bar (280 - 460 m) and up to 0.25 m of deposition on most of the profile seaward (460 - 780 m) of the storm bar.

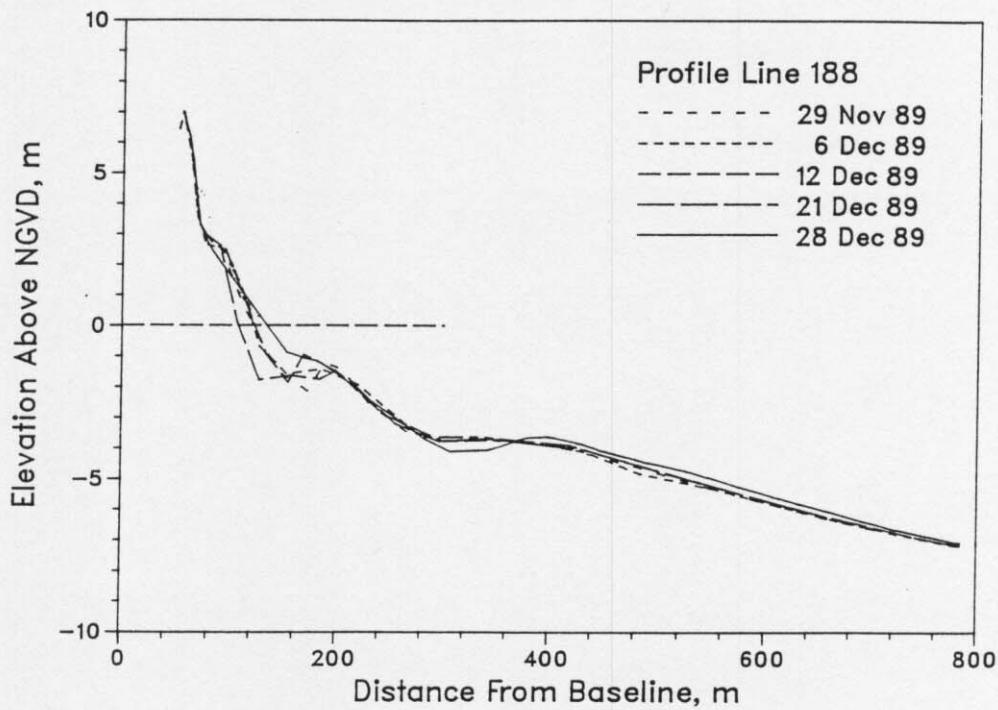


Figure 5. Monthly CRAB profiles on profile 188 - 517 m south of pier.

The profile envelope (Figure 6) reflects the maximum changes that occurred on the profile during 1989. Causes for the changes visible on the envelope include the steepening of the foreshore resulting in a deepening of the nearshore trough (120 m). The accretion which followed also changed the envelope (at the NGVD intercept) as did the offshore development of the storm bar (320 and 400 m).

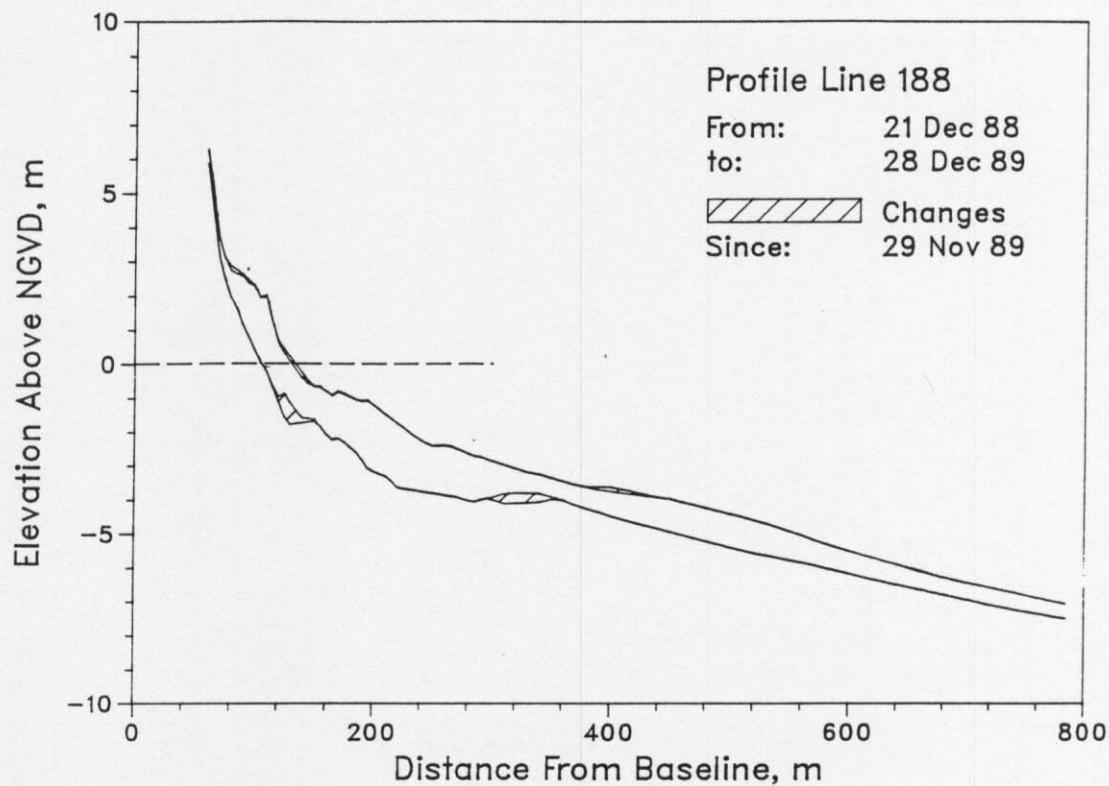


Figure 6. CRAB profile envelope - profile 188.

B. Bathymetry. Figure 7 includes a two- and three-dimensional contour map and a change plot derived from the bathymetric survey on 7 December. Wide contour lines on the change diagram represent eroded areas; thin lines indicate deposition.

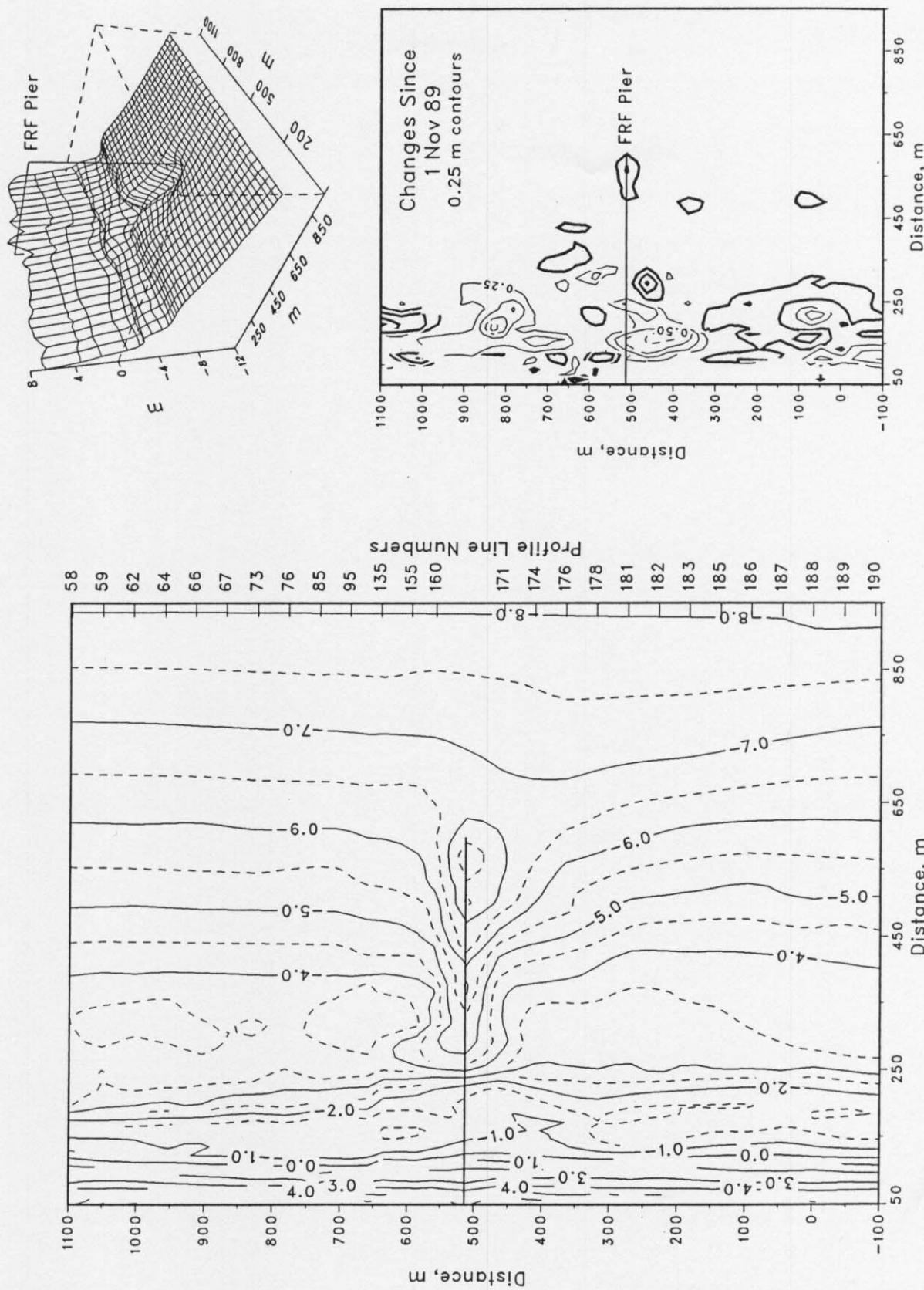


Figure 7. FRF bathymetry 7 Dec 89 depths relative to NGVD

PART VIII. SPECIAL EVENTS

A. Storm Data Collection. The following list identifies times when the significant wave height at the seaward end of the pier (i.e. as measured near the end of the pier) exceeded 2 m and four contiguous 34 minute wave records were obtained every three hours:

<u>Start</u>	<u>End</u>
8 Dec (1000)	10 Dec (1600)
13 Dec (0700)	13 Dec (2000)
22 Dec (0100)	22 Dec (1108)
23 Dec (1108)	25 Dec (2042)

B. Storm Synopsis.

8-10 December - Developing over Alabama early on 8 December, this storm quickly moved to the east, being located off North Carolina on 9 December. Maximum wind speeds (from northeast) exceeded 20 m/s at 2200 EST on 9 December. Earlier in the day at 0208 EST the peak H_{mo} (at gage 625) reached 3.05 m ($T_p = 9.85$ sec). The minimum atmospheric pressure of 1001.9 mb occurred at 2200 EST, also on 9 December. Total precipitation was 56 mm.

13 December - Developing in the Gulf of Mexico this small coastal storm rapidly moved into the Atlantic being located off Cape Hatteras, NC on 13 December. Recorded at 0808 EST the peak wind speed (from north) surpassed 13 m/s followed at 1334 EST by the maximum H_{mo} (at gage 625) of 2.46 m ($T_p = 9.48$ sec). The minimum atmospheric pressure of 1002.7 mb occurred at 0400 EST. Total precipitation was 19 mm.

22 December - Winds from a strong high pressure system located over the mid-western U.S. began to generate storm waves at the FRF early on 22 December. The maximum H_{mo} (at gage 111) of 2.31 m ($T_p = 6.74$ sec) was attained at 0208 EST with maximum winds (from north-northwest) of 14 m/s occurring at 0100 EST.

23-25 December - Reinforced by the same mid-western high pressure system which had produced storm waves on 22 December, a storm which developed off the Georgia coast on 23 December quickly intensified into a major blizzard. The storm destroyed several previously damaged ocean front cottages in the town of Kitty Hawk and produced gale force winds accompanied by significant quantities of snow. The maximum H_{mo} (at gage 111) of 4.67 m ($T_p = 10.67$ sec) was recorded at 1442 EST on 24 December. Offshore (at gage 630) the H_{mo} reached 5.63 m ($T_p = 11.13$) at 1300 EST the same day. Peak winds (from the north) approached 21 m/s at 0842 EST also on 24 December. Winds above 10 m/s were recorded for 39 consecutive hours. Since the center of the storm remained offshore the atmospheric pressure at the FRF dropped only to 1012.5 mb at 1142 EST on 24 December. Due to the strong winds the rain gages failed to collect much of the snowfall. Approximately 20-25 cm of snow fell at the FRF with up to 36 cm reported at other locations.

Distribution List

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